

## Additional Information for the South Coast On-Road Heavy-Duty Vehicle Incentive Measure

The California Air Resources Board's (CARB) *South Coast On-Road Heavy Duty Vehicle Incentive Measure* (South Coast Incentive Measure) includes three types of projects: drayage truck replacement projects, solid waste collection vehicle (refuse truck) replacement projects, and refuse repower projects.

The South Coast Incentive Measure *Appendix A South Coast Incentive Measure Methodology and Sample Calculations* provided sample calculations for two types of projects, Example 1 and 2. Example 1 is for a drayage truck replacement project and Example 2 is for a refuse truck replacement project. Refuse truck repower projects are calculated in the same manner as Example 1. CARB is providing additional information via Example 3 as a sample calculation for a refuse repower project. Examples 1, 2, and 3 cumulatively demonstrate that turning over 1,300 on-road heavy-duty vehicles will achieve one tpd of NOx reductions.

This information allows U.S. Environmental Protection Agency (U.S. EPA) to replicate CARB staff's calculation of one ton per day (tpd) of NOx emission reductions by turning over 1,300 on-road heavy-duty vehicles with currently available incentive funds.

Table 1, below, is a more detailed version of the table on page ES-2 of the measure.

**Table 1: Project Summary Based on Estimated Projections**

Example Calculation Reference	Project Types	Total Number of Projects*	NOx Emission Reduction Per Project (tpd)	Total NOx Emission Reductions (tpd)*
Example 1	Drayage Replacement	350	0.0004	0.14
Example 2	Refuse Replacement	500	0.0017	0.85
Example 3	Refuse Repower	450	0.00005	0.02
<b>Total</b>		<b>1,300</b>		<b>1.0</b>

Notes:

Calculations may not add up due to rounding

\*The 1,300 vehicles and one tpd of NOx reductions are totaled for all four years of implementation from 2019 to 2022

### Example 3 – Calculating Estimated Repower Project Emission Reductions

Example 3 calculates an estimated individual project using formulas<sup>1</sup> and emission factors<sup>2</sup> found in Appendix C and D of the 2017 Guidelines, respectively. The data points will be included in reports to U.S. EPA that will be publicly available at <https://www.arb.ca.gov/planning/sip/imp2016sip/imp2016sip.htm>. The list of the data points can be found in the South Coast Incentive Measure **V. Quantifiable** section.

<sup>1</sup> Formula C-5: *Estimated Annual Emissions Based on Mileage*

<sup>2</sup> Table D-5: *Diesel Refuse Trucks Emission Factors*

An applicant will scrap a 2009 engine model year (EMY) refuse truck and repower it with a 2019 engine model year engine certified to a 0.02 g/bhp-hr NOx engine standard. Emission rates for refuse trucks will be based on Table D-5. Note that refuse trucks do not include deterioration rates.

This project is eligible for a two-step cost-effectiveness calculation.

Step 1 – EMY 2009 to EMY 2010+ 0.20 g/bhp-hr NOx standard

Step 2 – EMY 2010+ 0.20 g/bhp-hr NOx standard to EMY 2019 0.02 g/bhp-hr NOx standard

Note: Calculations may not add up due to rounding.

#### Hypothetical data and inputs

Calendar Year: 2019

Vehicle Class: Refuse Truck

Model Year: 2009

Vehicle Miles Travelled: 16,000 miles/year

#### **Step 1**

##### **(a) Determine deterioration calculations for a EMY 2009 to EMY 2010+ 0.20 NOx (NOTE: REFUSE TRUCKS DO NOT HAVE DETERIORATION RATE)**

**Formula C-5:** Estimated annual emissions based on mileage (tons/year)  
*Annual emissions by pollutant (tons/year) = (emission factor (grams/mile) + deterioration product (grams/mile)) \* annual activity (miles/year) \* percentage operation in South Coast AQMD / 907,200 (grams/ton)*

##### **(1) Calculate deterioration life (baseline equipment) (years):**

*Deterioration life (baseline equipment) (years) = expected first year of operation – baseline engine model year + (project life/ 2)*

Deterioration life (baseline equipment) = 2019 – 2009 + (5 / 2) = 12.5 years

##### **(2) Calculate deterioration life (reduced equipment) (years):**

*Deterioration life (reduced equipment) (years) = project life / 2*

Deterioration life (reduced equipment) = 5 / 2 = 2.5 years

##### **(3) Calculate total equipment activity and cap the baseline equipment activity when applicable (mi):**

*Total equipment activity (miles) = annual activity (miles/year) \* deterioration life (years)*

Total baseline equipment activity = 16,000 (miles/year) \* 12.5 (years) =

200,000 miles

Total reduced equipment activity = 16,000 (miles/year) \* 2.5 (years) =  
40,000 miles

**(4) Calculate mile-based deterioration product for baseline and reduced equipment, for each pollutant (grams/mile):**

*Mile-based deterioration product (grams/mile) = deterioration rate (grams/mile-10,000 mile) \* total equipment activity (mile)*

**Baseline equipment:**

NOx deterioration product = (NO RATE) (grams/mile-10,000 mile) \*  
200,000 (miles) = 0 grams/mile

**Reduced equipment:**

NOx deterioration product = (NO RATE) (grams/mile-10,000 mile) \* 40,000 (mile)  
= 0 grams/mile

**(b) Determine emission reductions calculations for a EMY 2009 to EMY 2010+ 0.20 NOx engine:**

**(1) Calculate the estimated annual emissions for baseline and reduced equipment, for each pollutant (tons/year):**

**Formula C-5:** Estimated annual emissions based on mileage (tons/year)  
*Annual emissions by pollutant (tons/year) = (emission factor (grams/mile) + deterioration product (grams/mile)) \* annual activity (miles/year) \* percentage operation in South Coast AQMD / 907,200 (grams/ton)*

Annual NOx **baseline** technology emissions (tons/year)  
(1.23 (grams/mile) + 0 (grams/mile)) \* 16,000 (miles/year) \* 100% / 907,200 (grams/ton)  
= 0.0217 tons/year

Annual NOx **reduced** technology emissions (tons/year)  
(1.09 (grams/mile) + 0 (grams/mile)) \* 16,000 (miles/year) \* 100% / 907,200 (grams/ton)  
= 0.0192 tons/year

**(2) Calculate annual surplus emission reductions for each pollutant (tons/year):**

**Formula C-9:** Annual surplus emission reductions (tons/year)  
*Annual surplus emission reductions by pollutant (tons/year) = annual emissions for the baseline technology (tons/year) – annual emissions for the reduced technology (tons/year)*

Transaction 1: Annual NOx surplus emission reductions (tons/year) =  
0.0217 (tons/year) - 0.0192 (tons/year) = 0.0025 tons/year

## Step 2

### (c) Determine deterioration calculations for a EMY 2010+ 0.20 NOx engine to EMY 2019 0.02 NOx engine:

**Formula C-5:** Estimated annual emissions based on mileage (tons/year)  
*Annual emissions by pollutant (tons/year) = (emission factor (grams/mile) + deterioration product (g/mi)) \* annual activity (mi/year) \* percentage operation in South Coast AQMD / 907,200 (g/ton)*

#### (1) **Calculate deterioration life (baseline equipment) (years):**

*Deterioration life (baseline equipment) (years) = expected first year of operation – baseline engine model year + (project life / 2)*

Deterioration life (baseline equipment) = 2019 – 2019 + (5 / 2) = 2.5 years

#### (2) **Calculate deterioration life (reduced equipment) (years):**

*Deterioration life (reduced equipment) (years) = project life / 2*

Deterioration life (reduced equipment) = 5 / 2 = 2.5 years

#### (3) **Calculate total equipment activity and cap the baseline equipment activity when applicable (miles):**

*Total equipment activity (miles) = annual activity (miles/yr) \* deterioration life (years)*

Total baseline equipment activity = 16,000 (miles/year) \* 2.5 (years) = 40,000 mi

Total reduced equipment activity = 16,000 (miles/year) \* 2.5 (years) = 40,000 mi

#### (4) **Calculate deterioration product for baseline and reduced equipment, for each pollutant (grams/mile):**

*Mile-based deterioration product (grams/mile) = deterioration rate (grams/mile-10,000 mi) \* total equipment activity (mile)*

##### **Baseline equipment:**

NOx deterioration product = (NO RATE) (grams/mile-10,000 mile) \*  
40,000 (miles) = 0 grams/mile

**Reduced equipment:**

NOx deterioration product = (NO RATE) (grams/mile-10,000 mile) \*  
40,000 (miles) = 0 grams/mile

**(d) Determine emission reductions calculations for a EMY 2010+ 0.20 NOx engine to EMY 2019 0.02 NOx engine:**

**(1) Calculate the estimated annual emissions for baseline and reduced equipment, for each pollutant (tons/year):**

**Formula C-5:** Estimated annual emissions based on mileage (tons/year):  
*Annual emissions by pollutant (tons/year) = (emission factor (grams/mile) + deterioration product (grams/mi)) \* annual activity (miles/year) \* percentage operation in South Coast AQMD / 907,200 (grams/ton)*

Annual NOx **baseline** technology emissions (tons/year)  
(1.09 (grams/mile) + 0 (grams/mile)) \* 16,000 (miles/year) \*  
100% / 907,200 (grams/ton)  
= 0.0192 tons/yr

Annual NOx **reduced** technology emissions (tons/year)  
(.11 (grams/mile) + 0 (grams/mile)) \* 16,000 (miles/year) \*  
100% / 907,200 (grams/ton)  
= 0.0019 tons/yr

**(2) Calculate annual surplus emission reductions for each pollutant (tons/yr):**

**Formula C-9:** Annual surplus emission reductions (tons/year)  
*Annual surplus emission reductions by pollutant (tons/year) = annual emissions for the baseline technology (tons/year) – annual emissions for the reduced technology (tons/year)*

Transaction 2: Annual NOx surplus emission reductions (tons/year) =  
0.0192 (tons/year) - 0.0019 (tons/year) = 0.0173 tons/year

**(e) Determine the total NOx emission reductions for total project life**

**Formula C-15:** split project lives

*Total annual weighted surplus emission reductions (tons/year) = (fraction project life / total project life \* annual weighted surplus emission from transaction 1) + (fraction project life / total project life \* annual weighted surplus emission from transaction 2)*

Total annual NOx weighted surplus emission reductions =  
0.0025 tons/year \* (5 / 5) + 0.0173 tons/yr \* (5 / 5) = 0.0198 tons/year

(f) **Convert tons per year to tons per day**  
 $(\text{tons/day}) = (\text{tons/year}) * (1 \text{ year}/365 \text{ day})$

$$0.0198 \text{ tons/year} * (\text{year}/365 \text{ day}) = .00005 \text{ tons per day}$$